SUMMER DIET OF INDIAN GIANT FLYING SQUIRREL *PETAURISTA PHILIPPENSIS* (ELLIOT) IN SITAMATA WILDLIFE SANCTUARY, RAJASTHAN, INDIA

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Summer feeding habit of the Indian Giant Flying Squirrel *Petaurista philippensis* was studied from March 2009 to June 2009 in Sitamata Wildlife Sanctuary. These squirrels are arboreal and entirely depend on plant material. Of 2,157 feeding records, 13 plant species from 10 families were identified in their feeding behaviour. Used food items were piths (58.59%), twigs (16.87%), leaves (5.09%), bark (2.64%), flowers (5.23%), buds (4.82%), fruits (6.44%) and seeds (0.27%). Mahuwa *Madhuca longifolia* was a predominant species in their feeding. They are early rising and use their early active time in feeding after which their activity lowers during night.

Key words: *Petaurista philippensis*, arboreal, feeding behaviour, *Madhuca longifolia*

INTRODUCTION

Food is one of the most important resources for growth, reproduction and survival of animals. Consequently, animals that are generally herbivores, respond to spatial and temporal variability of food availability by selecting specific feeding habitats (McNaughton 1990; Wilmshurst *et al.* 1999; Ball *et al.* 2000) and diet (Hanley 1997; Dumont *et al.* 2002). Dietary variation occurs in response to plant phenology and changes in availability of resources (Poulsen *et al.* 2001). Impact of plant phenology on primary consumers has gained much attention in recent years (Van Schaik *et al.* 1993; White 1998; Curran and Leighton 2000).

Flying squirrels (Rodentia: Sciuridae: Petauristainae) are nocturnal gliding mammals, comprising of 12 genera and 43 species (Eisenberg 1981). Only one species of flying squirrel is found in Europe and north Asia, and two species in North America. Species richness peaks in the South-east Asian countries (Lee and Liao 1998; Nandini 2001). Eleven species are found in India, most of which are concentrated in the Himalayan, the North-east regions and the Western Ghats (Nandini 2001).

Petaurista philippensis has a wide distribution and occurs in most forests of peninsular India (Prater 1971; Agarwal and Chakraborty 1979; Wilson and Reeder 1993). Southern Rajasthan is a distinct patch for the occurrence of *P. philippensis*. Tehsin (1980) and Chundawat *et al.* (2002) reported the presence of Large Brown Flying Squirrel in Phulwari Wildlife Sanctuary in Udaipur district of Rajasthan. Sitamata Wildlife Sanctuary is also a prominent area of distribution of *P. philippensis* in southern Rajasthan.

In Rajasthan, climate ranges from arid to semiarid and the rainfall is very low and erratic. During summer, the sun shines directly upon Tropic of Cancer, which increases the temperature (32°C to 40°C) in southern Rajasthan; the subtropical forest replaces the tropical deciduous forest, and water and food availability becomes low. Summer, therefore, is a very critical time for *Petaurista philippensis* for survival. This study was carried out to understand how *P. philippensis* copes with unfavourable situations and was confined to its food availability, food preference and diet during summer.

STUDY AREA

The study was carried out in the Sitamata Wildlife Sanctuary (Fig. 1), which is situated between 24° 04'-24° 23' N and 74° 25'-74° 40' E. The Sanctuary covers an area of 422.95 sq. km. It is situated in the south-eastern region of Rajasthan where three very ancient mountain ranges of India meet forming a teak forest. The configuration of land is hilly and rugged with altitude varying from 280 to 600 m. The general slope of the land is from North-West to South-East. Forest with subtropical feature is characterized by distinct winter, summer and rainy seasons. Average rainfall is 756 mm and the temperature ranges between 6°C in winter and 45°C in summer. The Sanctuary harbours nearly 50 species of mammals, 275 species of birds, 40 species of reptiles, 9 species of amphibians, 30 species of fishes and more than 800 species of plants (Kartikeya 2005).

MATERIAL AND METHODS

The present study was carried out during summer between March and June 2009. Four flying squirrel sites,

Fig. 1: Map of Sitamata Wildlife Sanctuary (Study area)

which they inhabited permanently, were identified and marked (Table 1). Identification of sites where squirrels were present was done using two procedures. Initially the area was thoroughly explored to locate the squirrel inhabited trees and sites. These were later confirmed by the forest personnel and by exploring the area at regular time intervals. The sites were visited fortnightly with a minimum of five days stay in the field during each visit in fifteen days and eight nights in one month. Being nocturnal and arboreal, the flying squirrel is hard to locate during night. They were detected by eyeshine and calls, and occasionally by their movement on or between trees. Every night around dusk, vigilant move was carried along a trail, which meandered through the study area. Binocular and spotlight (NS-8300DX) with a Swiss handle and stand were used to observe the flying squirrel.

Behaviour of individual flying squirrel was recorded using Focal Animal Sampling Method (Altmann 1974). In this method occurrence of specified actions (feeding) of an individual were recorded during each sample period. A record was made of the length of each period and for each focal individual. The amount of time during the sample was actually in view. Once chosen, a focal individual was followed to whatever extent possible during each of the sample periods. The data was recorded at five second intervals from the time the squirrel started feeding.

Phenological data were also collected monthly during the study period. The data was taken to assess the association between abundance of plant parts and composition of the diet of the flying squirrel. Phenology of plant species was categorized into two phases: vegetative phase and reproductive phase. Vegetative phase was further sub-categorized into piths, twigs, leaves and bark, while reproductive phase was sub-categorized into buds, flowers, fruits and seeds.

RESULTS

A total of 2,153 feeding records were collected during 304 hrs of field observation with a mean (± SE) of 538 ±97.94 records/month (Range = 0-467). The flying squirrel consumed 8 plant parts from 13 species belonging to 10 families (Table 2). Most feeding records were from Sapotaceae (33.14%), Combretaceae (33.14%), Anacardiaceae (8.71%), Moraceae (7.27%), Ebenaceae (7.09%), whereas other families contributed a smaller amount. Three families, namely Moraceae, Combretaceae and Anacardiaceae include two species each, while other families had one species each.

Six species of trees including *Mangifera indica*, *Mitragyna parviflora*, *Alvizia odoratissima*, *Cordia myxa*, *Tectona grandis* and *Sarcopetalum tomentosa* contributed < 5% (range 0.27-3.29%) and 2 species of trees including *Madhuca longifolia* and *Terminalia bellirica* contributed >20% (range 510-715 of the 2,157 feeding records). Remaining species contributed between 5 to 10% of feeding records. *Madhuca longifolia* was a predominant species for

Table 1: Location of Flying squirrel sites in Sitamata Wildlife Sanctuary

S. No.	Site	Location	Nesting tree
1	Arampura naka 1	24°13' 19" N, 74°25' 54" E	*Madhuca longifolia*
2	Arampura naka 2	24°13' 21" N, 74°25' 53" E	*Madhuca longifolia*
3	Lambi samel	24°13' 07" N, 74°25' 36" E	*Madhuca longifolia*
4	Kunda nala	24°13' 39" N, 74°25' 55" E	*Terminalia bellirica*

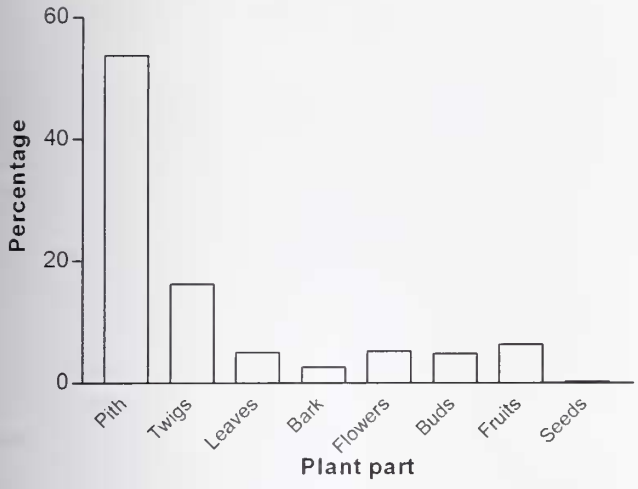

Fig. 2: Percentage observation of plant parts in the diet of the Flying squirrel during summer season

feeding and it contributed 33.14% of feeding records and *Tectona grandis* contributed only 0.27% and ranked 13 in the list. Both *Madhuca longifolia* and *Terminalia bellirica* species contributed more than half of the feeding records.

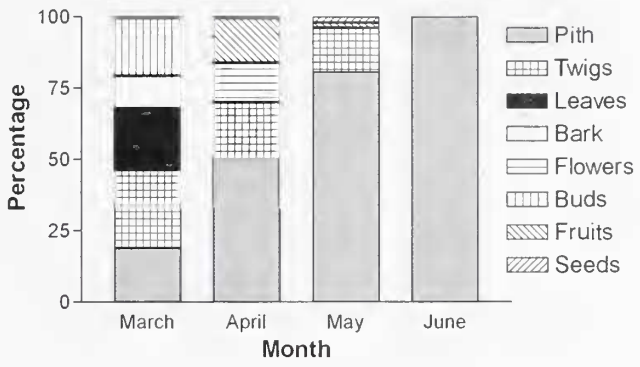

Fig. 3: Monthly diet composition of the flying squirrel

Eight food items were consumed by the flying squirrel during the study period. Pith was most frequently (58.59%) consumed, followed by twigs (16.87%), fruits (6.44%), flowers (5.23%), leaves (5.09%),buds (4.82%), bark (2.64%) and seeds (0.27%) (Fig. 2). Pith was obtained from 10 plant species, twigs from 7 plant species, leaves and fruits from 2 plant species, bark, flowers and buds were obtained from only *Madhuca longifolia*. Seeds were least preferred and obtained from *Tectona grandis* (Table 2).

Table 2: Plant species and part consumed by *Petaurista philippensis* at Sitamata Wildlife Sanctuary (Rajasthan) during summer in 2009

S.No.	Family	Species	Part	Phenophase*	% Feeding time	Rank
1	Ebenaceae	*Diospyros melanoxylon*	Twig	imm	7.09	5
			Pith	-		
2	Sapotaceae	*Madhuca longifolia*	Bark	imm	33.14	1
			Buds	-		
			Pith	-		
			Fruit	r, sr, ur		
			Flower	m, imm		
			Twig	imm		
3	Combretaceae	*Terminalia tomentosa*	Leaf	imm	9.50	3
			Pith	-		
		Terminalia bellirica	Twig	imm	23.64	2
			Leaf	imm		
			Pith	-		
4	Anacardiaceae	*Lannea coromandelica*	Pith	-	5.42	6
		Mangifera indica	Pith	-	3.29	8
5	Moraceae	*Ficus religiosa*	Twig	imm	7.27	4
			Pith	-		
		Ficus bengalensis	Pith	-	5.33	7
6	Rubiaceae	*Mitragyna parviflora*	Twig	imm	2.41	9
			Pith	-		
7	Fabaceae	*Alvizia odoratissima*	Twig	imm	0.92	11
8	Boraginaceae	*Cordia myxa*	Fruit	m	0.69	12
9	Lamiaceae	*Tectona grandis*	Seed	m	0.27	13
10	Menispermaceae	*Sarcopetalum tomentosa*	Twig	imm	1.20	10
			Pith	-		

*Codes for phenological phase of plant parts consumed.
imm = immature; m = mature; ur = unripe; sr = partly ripe; r = ripe

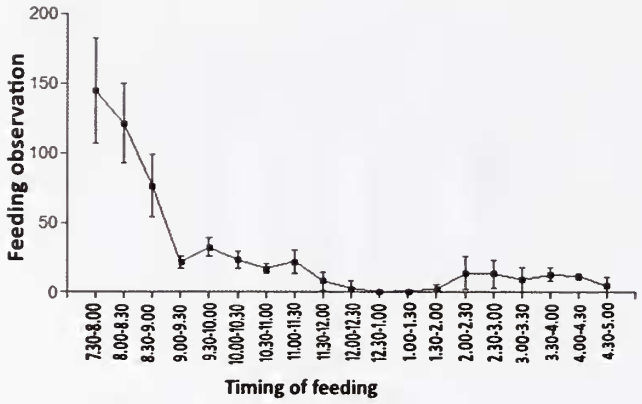

Fig. 4: Feeding time of the Flying squirrel during their active period (7.30 pm-5.00 am)

It was also observed that in March only 5 food parts were used in 508 feeding records. The most preferred feeding plant part was twigs, which comprised 27.95% of the monthly feeding records. This was followed by leaves (21.65%), buds (20.47%) and pith (18.70%) (Fig. 3, Table 3). In April, 4 food items were used in 817 feeding records and the percentage of pith increased and reached 50.30% which was followed by twigs (19.95%), fruits (15.91%) and flowers (13.83%). Use of pith further increased in May reaching 80.60% with 361 feeding records. Except pith other food parts were twigs (15.78%), fruits (1.93%) and seeds (1.66%). In June, the only feeding part was pith which comprised 100% of the monthly feeding records.

The feeding time of the flying squirrel is shown in Fig. 4. The most active time of feeding was when flying squirrels emerged from their holes. After emerging, they started feeding. Feeding became less around 00:30 hrs. Between 00:30 hrs and 02:00 hrs, the feeding activity ceased. Feeding resumed after 02:00 hrs, but the frequency was low. Thus, the peak time of feeding was 19:30 to 21:30 hrs while 24:00 to 02:00 hrs was resting time.

DISCUSSION

The flying squirrel fed primarily on pith in summer besides twigs, leaves, bark, flowers, buds, fruits and seeds. Other studies on the diet of the flying squirrel also show that they are largelyfolivorous (Lee *et al.* 1986; Kawamichi 1997; Kuo and Lee 2003; Nandini and Parthasarathy 2008). The flying squirrel is a selective forager and only 13 plant species and 8 plant parts were consumed in their summer diet. Besides they consumed the part only from a few plant species in each month. Some species of plants were used more whereas others were used sporadically emphasizing its preference. Kuo and Lee (2003) showed that the flying squirrel consumed at least 79 species-specific parts of plants belonging to 30 families, and Nandini and Parthasarathy (2008) reported that 25 different plant parts of 10 tree species were recorded in the feeding of the flying squirrel. Japanese Giant Flying Squirrels *P. leucogenys* were also found to be highly selective feeders (Ando *et al.* 1985; Kawamichi 1997). Janzen (1978) and Kuo and Lee (2003) stated that, relative to terrestrial animals, arboreal species are unable to store large amounts of fat, which would restrict their movements and increase the risk of falling. Furthermore, because arboreal folivores rely on relatively poor quality food, they may be constrained by their ability to convert energy (Eisenberg 1978; Kuo and Lee 2003).

In this study, the flying squirrel preferred to feed on pith, as it comprised 58.59% of its diet. Pith is the central part of stem or twig which is rich in water content and nutrition. This content fulfils the requirement of water for flying squirrel in summer. Immature leaves were used during March. Coley (1983) showed that young and mature leaves of pioneer species contain fewer digestion reducers such as cellulose, tannins, and lignin and are relatively palatable to herbivores.

Table 3: Data on different plant parts consumed each month and their monthly percentages

Plant part	March		April		May		June	
	No. of observations	%	No. of observations	%	No. of observations	%	No. of observations	%
Pith	95	18.70	411	50.30	291	80.60	467	100
Twigs	142	27.95	163	19.95	57	15.78	-	-
Leaves	110	21.65	-	-	-	-	-	-
Bark	57	11.22	-	-	-	-	-	-
Flowers	-	-	113	13.83	-	-	-	-
Buds	104	20.47	-		-	-	-	-
Fruits	-	-	130	15.91	7	1.93	-	-
Seeds	-	-	-	-	6	1.66	-	-
Total	508	-	817	-	361	-	467	-

Nandini and Parthasarathy (2008) revealed that fruit was most usable plant part for the flying squirrel, in the Western Ghats, which constituted 48.42% of all plant parts. The difference in feeding parts of plants may be because, the habitat of the flying squirrel in the Western Ghats has more humid area and the squirrel does not require to conserve water. In the present study, water conservation by the animal is much required as the forest is of dry deciduous type. Thus, the flying squirrel consumed a wide variety of plant parts. The diet of the flying squirrel changed in relation to plant phenology. This habit is related to availability of food and composition of forest. For example, reproductive phase of *Madhuca longifolia* is fixed in annual time period, so, flying squirrel used their phase parts (bud, flower and fruit) in March and April; bark was used in March. Thin bark is often removed to the depth of the cambium, but thicker bark may not be (MacKinnon 1978). Some seeds or fruits are produced relatively early in summer, which may contribute to the food available for young squirrels (Thompson and Thompson 1980). Giant flying squirrels also shifted to other food items, even when a previously known food item was still available. This was usually because a newly available food item was more preferable; in particular, a rapid shift from mature leaves to swelling buds (in March), and a successive change from one species of oak to another in search of new leaves or acorns due to their slightly different periods of leaf out and seed production (Kawamichi 1997). No significant relationship was found between availability of parts of plants and feeding frequency, implying that Indian Giant Flying squirrels did not select food on the basis of total availability. Similar observations were reported by Kuo and Lee (2003). During the present study, no occasion was witnessed when the flying squirrel fed on food of animal origin. Similar observations were also noted by Kawamichi (1997), Nandini and Parthasarathy (2008) and Kuo and Lee (2003).

According to Nandini (2001), flying squirrels begin feeding around 18:30 hrs, while in this case both feeding and calling began around 19:00 hrs. Feeding dropped around 22:00 hrs. At 22:00 hrs most individuals were noticed either calling or sitting. The present study also showed that most active feeding time was from 19:30 to 21:30 hrs that reduced till 24:00 hrs, while after 02:00 hrs some feeding was observed.

Thus, from the present study it can be inferred that Mahuwa *Madhuca longifolia* is the most preferred plant with respect to feeding and pith is the preferred plant part.

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